

What is claimed is:

1. A packetized-data processing apparatus comprising:  
a memory configured to store core groups of packetized data;  
a channel coupled to the memory and having a total bandwidth for transferring packets of data from the core groups; and  
a scheduler operatively coupled to the memory and the channel and configured to allocate amounts of the total bandwidth of the channel to each of the core groups that is backlogged, while limiting the amount of allocated bandwidth, and a corresponding transfer rate of packets of data, for each core group to a maximum allowable bandwidth for each core group, to schedule transfer of packetized data of the core groups from the memory to the channel in accordance with the respective amounts of allocated bandwidth for the core groups.
2. The apparatus of claim 1 wherein the scheduler is configured to allocate channel bandwidth to a dummy group.
3. The apparatus of claim 2 wherein the channel bandwidth allocated to the dummy group is dependent upon an amount of backlogged core groups.
4. The apparatus of claim 3 wherein the dummy group is allocated zero bandwidth if all core groups are backlogged.

5. The apparatus of claim 3 wherein the channel bandwidth allocated to the dummy group is also dependent upon weightings of bandwidth allocation associated with the core groups and upon at least one maximum allowable bandwidth associated with at least one of the core groups.

6. The apparatus of claim 5 wherein the dummy group is allocated zero bandwidth if the total channel bandwidth is allocatable to only core backlogged groups in accordance with their relative bandwidth weightings without exceeding their respective maximum allowable bandwidths.

7. The apparatus of claim 5 wherein the dummy group is allocated at least an amount of the total channel bandwidth equaling a sum of the respective maximum allowable bandwidths of backlogged core groups.

8. The apparatus of claim 7 wherein the dummy group is allocated bandwidth according to  $Q(B_{\text{total}}/B_{\text{max}} - M')$ , where  $B_{\text{total}}$  is the total channel bandwidth,  $B_{\text{max}}$  is the maximum allowable bandwidth for each of the core groups,  $M'$  is the amount of backlogged core groups, and  $Q$  is a weighting of core groups.

9. The apparatus of claim 2 wherein the scheduler is configured to determine an amount of bandwidth to allocate to the dummy group each time a backlog state of a core group changes.

10. The apparatus of claim 1 wherein the core groups are classes of queues of packets of data.

11. The apparatus of claim 1 wherein the core groups are queues of packets of data.

12. A computer program product, for use with a communications channel having a total bandwidth and a memory for storing core groups of packets of data, the computer program product comprising instructions for causing a computer to:

obtain an indication of an amount of backlogged core groups;

allocate first portions of the total bandwidth of the channel to a plurality of backlogged core groups according to weights associated with each backlogged core group; and

allocate a second portion of the total bandwidth of the channel to a dummy group, the second portion being at least as large as an amount of the total bandwidth that exceeds a cumulative bandwidth of maximum bandwidths associated with the plurality of backlogged core groups.

13. The computer program product of claim 12 wherein the instructions for causing a computer to allocate bandwidth cause the computer to allocate bandwidth in response to a core group changing backlogged state.

14. The computer program product of claim 12 wherein the second portion is zero bandwidth if the total channel bandwidth is allocatable to only core backlogged groups in

accordance with their relative bandwidth weights without exceeding respective maximum allowable bandwidths of the core backlogged groups.

15. The computer program product of claim 12 wherein the second portion is dependent upon at least one maximum allowable bandwidth associated with at least one of the core groups.

16. The computer program product of claim 12 wherein the second portion is  $Q(B_{\text{total}}/B_{\text{max}} - M')$ , where  $B_{\text{total}}$  is the total channel bandwidth,  $B_{\text{max}}$  is a maximum allowable bandwidth for each of the core groups,  $M'$  is an amount of backlogged core groups, and  $Q$  is a weighting of core groups.

17. A method of transferring data packets from a plurality of groups for storing packets of data and a transmission channel having a total bandwidth, the method comprising:  
obtaining an indication of an amount of backlogged groups from among the plurality of groups;

allocating first portions of the total bandwidth of the channel to a plurality of backlogged groups according to weights associated with each backlogged group; and

allocating a second portion of the total bandwidth of the channel to be unused, the second portion being at least as large as an amount of the total bandwidth that exceeds a cumulative bandwidth of maximum bandwidths associated with the plurality of backlogged groups.

18. The method of claim 17 wherein the allocating of the first portions and the second portion occur in response to a group changing backlogged state.

19. The method of claim 17 wherein the second portion is zero bandwidth if the total channel bandwidth is allocatable to only backlogged groups in accordance with their relative bandwidth weights without exceeding respective maximum allowable bandwidths of the backlogged groups.

20. The method of claim 17 wherein the second portion is dependent upon at least one maximum allowable bandwidth associated with at least one of the groups.

21. The method of claim 17 wherein the second portion is  $Q(B_{\text{total}}/B_{\text{max}} - M')$ , where  $B_{\text{total}}$  is the total channel bandwidth,  $B_{\text{max}}$  is a maximum allowable bandwidth for each of the groups,  $M'$  is an amount of backlogged groups, and  $Q$  is a weighting of groups.

22. A system for transferring packets of data, the system comprising:  
at least one input port configured to receive packets of data;  
a storage device coupled to the at least one input port and configured to store groups of packets of data received at the at least one input port;  
at least one output port coupled to the storage device and configured to transmit packets of data stored in the storage device; and  
control means for controlling amounts of bandwidth of the output port provided for each of the groups for transferring the packets of data via the output port, the amount of bandwidth

provided for each group varying with a number of groups containing packets of data and being limited to a maximum amount of bandwidth associated with each group.

23. The system of claim 22 wherein the control means controls the amounts of bandwidths for each group by applying a weighted deficit round robin algorithm.

24. The system of claim 23 wherein the weighted deficit round robin algorithm includes a dummy for which the control means provides bandwidth to limit rates at which packets of data are transferred from the groups.